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Interface Data Processing Segment (IDPS) Functional Description Document (FDD)

Excerpts

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Prepared for the

NPOESS Integrated Program Office
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Excerpts: Interface Data Processing Segment (IDPS) Functional Description Document (FDD)[1]

Table of Contents

[1] Basic contents for external release.

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Tables

Figures

1 Introduction

1.1 Identification

This Interface Data Processing Segment (IDPS) Functional Description Document (FDD) is the top-level description of the IDPS of the National Polar-orbiting Operational Environmental Satellite System (NPOESS). From it and the top-level system requirements, the IDPS performance and interface requirements will be derived.

1.2 Purpose

The purpose of this document is to define the scope of the IDPS.

In its present form, this document is to serve as the basis for further discussion of the IDPS within the IPO. It will be used to clarify organizational and technical interactions among NPOESS components and the organizations that develop, build, and operate them. It is being used as a structured outline of the IDPS, and a repository of evolving notes which describe its components.

Eventually, the FDD should document the high-level description of the IDPS element. It will support the development of segment specifications, initially by IPO and subsequently by contractors.

The FDD should be used for guidance, not contractual direction.

1.3 Scope

The FDD describes all elements of NPOESS that complete returned mission data processing. This includes identification of elements provided by others. It does not include the Command, Control, and Communications Segment (C3S) (including ground stations, satellite operations, Data Routing and Retrieval [DRR], and simulator) or the Launch Support Segment.

The FDD emphasizes the functional IDPS description as it relates to Centrals. IDPS for DoD field terminals (IDP-F) is discussed explicitly at several points. IDPS characteristics applicable only to performance at Centrals is called IDP-C.

The IDPS Interface Description Document is a companion to this FDD. It will include auxiliary data descriptions and internal and external IDPS interface descriptions.

1.4 Document organization

Section 1 provides the environment within which the IDPS is to be defined. Section 2 proposes the conceptual outline for IDPS. Section 3 includes the functions to be performed, organized by communications, storage, and processing. Section 4 discusses at a high level the interfaces between IDPS and its environment. Details will be found in the *Interface Description Document*.

Sections 5-9 are placeholders for related issues and future content.

Appendix A will be an evolving list of open issues, explicitly or implicitly suggested in the text. Appendices B & C clarify terms used in the text. Appendix D [will] summarize the notional processing requirements (input-process-output) to produce all EDRs and the SDRs which lead to them.

1.5 Reference documents

W. Thorpe, *A Guide to WMO Code Form FM 94 BUFR*, FCM-16-1995, Office of the Federal Coordinator for Meteorology, March 1995, available at URL: <http://www.ofcm.gov/BUFR/BUFR.HTM>.

1.6 Applicable documents

NPOESS Joint Agency Requirements Group (JARG), *Integrated Operational Requirements Document (IORD) I*, 26 March 1996 (revised through August 1996).

Integrated Program Office, *Draft System Technical Requirements Document*, Version 3, 17 March 1997

Citations from the TRD are for reference only. Differences between this FDD and the TRD will be noted when they are known. The FDD must be made consistent with the TRD when the latter is approved.

Command and Control, Communications, and Computers Intelligence, Surveillance, and Reconnaissance (C4ISR) Architecture Framework (v2.0), will be used as documentation guidance for this FDD

Department of Defense, *Joint Technical Architecture, Version 2.0*, 26 May 1998

1.7 Current system descriptions

{This section will also include planned changes by current operators before installing NPOESS IDPS.}

1.7.1 POES[2]

NOAA polar satellite data is played back to the CDAs at Gilmore Creek near Fairbanks, AK and Wallops, VA. It is relayed via domsat at 2.66 Mbps to NESDIS facilities at Suitland, MD. After passing through the Satellite Operations Control Center (SOCC), the data stream goes to the Central EnvironMental Satellite Control System (CEMSCS), where it is ingested on an SGI Challenge workstation, and further processed on an IBM ES9000. The first step is to produce two Level 1A data sets[3]: one (AVHRR-1A) containing imagery only, and the second (AIP-1A) containing all other data. The 1A data sets are passed through "preprocessors" to produce 1B data sets for all instruments. The Level 1B products are archived, distributed to external users, and processed into NESDIS standard products (images, sea surface temperature [SST], global vegetation index, aerosols, radiation balance, ozone, snow/ice, atmospheric temperature and moisture profiles, and surface hydrology). This latter work is offloaded onto a Cray J916 and additional workstations.

Real-time data from POES is broadcast ... {more}

{more at http://psbsgi1.nesdis.noaa.gov:8080/KLM/PDP/PDP.html}

1.7.2 DMSP[4]

As a product of early convergence, DMSP polar satellite data is received at the same CDAs as used by NOAA, plus selected AFSCN stations. The data goes via ??? to AFWA. The DMSP Data Reconstruction System separates light and thermal imagery from OLS, and special sensor data. All three data streams are archived in the Central Data Base for local and remote users. The Satellite Data Handling System (SDHS) combines DMSP data with other sources to produce weather products. {need more details}

Real-time data from DMSP is broadcast ... {more}

1.7.3 METOP and IJPS

{Describe operational data flow, as it may relate to NPOESS.}

1.7.4 Information product exchanges

Operational and experimental polar products are currently exchanged among Centrals under a Shared Processing

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[2] P. M. Taylor and B. A. Banks, *An Overview of the NOAA/NESDIS Data Processing Systems and Derived Products for NOAA-KLM*, 78th Ann. Mtng. AMS, Phoenix, 11-16 January 1998.

Robert Mairs, *Central Satellite Data Processing*, OSDPD presentation to IPO, 15 September 1997.

[3] NOAA definitions for "Level 1A" and "Level 1B" data products do not correspond to NASA definitions of the same named products.

In NOAA usage, "Level 1B datasets [for an individual instrument] contain earth located, time-tagged instrument counts with calculated calibration parameters appended." This seems to correspond most closely to our RDR.

[4] *DMSP Overview*, at <http://www.aero.org/dmsp/overview/index.html>

Program (SPP)[5]. {more} The standards and procedures adopted by the Centrals for SPP and related cooperative activities may serve as a basis for xDR product exchange between IDPS and the Centrals.

[5] McCreary, Mac, *Program Operations Manual for the NOAA/DoD Shared Processing Program*, NOAA/NESDIS Information Processing Division, 30 September 1998.

2 IDPS Overview

2.1 Functions

The IDPS performs those functions that are required to convert the NPOESS spacecraft raw data stream into EDRs with high quality and reliability. The IDPS provides processing, storage, external connectivity, and information management services. The services need to be implemented with sufficient flexibility that the IDPS can be hosted at Central processing facilities and DoD field terminals. The hosting location can specify the specific subset of functions to be performed at that site, consistent with the site's performance needs as provided in the IORD, and available resources.

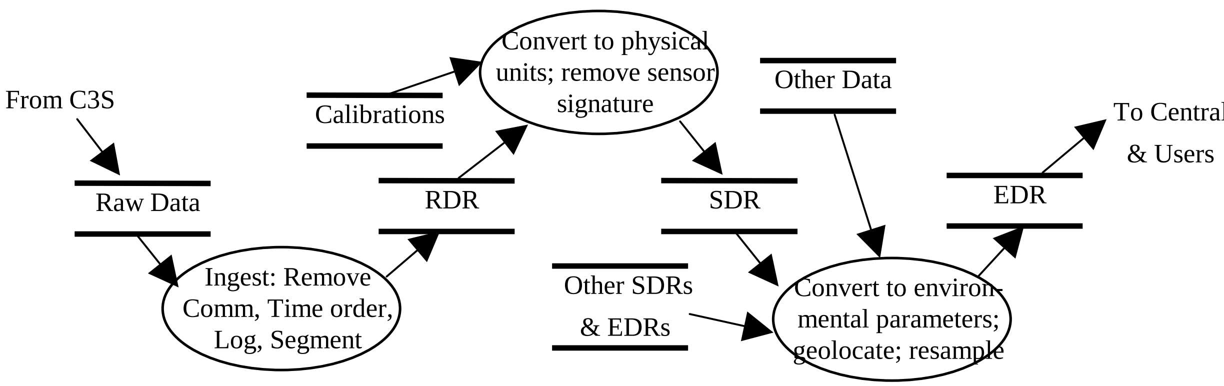

Figure 2-1. Generic IDPS Data Flow[6]

2.2 Notional Architecture

The IDPS is planned for collocation at five designated existing Centrals. Processing is duplicated at each Central which needs a copy of any xDR product.

Each site will receive all NPOESS data. Incoming data will be ingested as it becomes available, and held by a data server in an hierarchical storage array (tape, optical disk, hard disk, RAM, *etc*.). A high speed network will allow the data to be accessed by processors. The processors contain appropriate local storage, and host the algorithms to produce the subset of raw data records (RDRs), sensor data records (SDRs), and environmental data records (EDRs) for that site. The local architecture should be designed with consideration of site processing needs, such as whether processors will be shared among processes or dedicated; general purpose or specialized (*e.g*., array or multi-processors, digital signal processors [DSPs]); and whether skilled operator interpretation may be needed.

Information management and system control will be implemented locally, to assure that all data records (xDRs) are produced in a timely manner from the best available sources, using the available resources as efficiently as possible.

Standard data products will be delivered to the existing Centrals from the IDPS data server.

To the greatest extent possible, the same IDPS functions will be incorporated in DoD field terminals, using available terminal resources. The IDPS functionality will be incorporated in upgraded DoD field terminals,

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[6] RDRs and SDRs, in addition to EDRs, are delivered to designated users, including Centrals and DoD terminals.

where IDPS processing will provide EDRs for supplementary meteorological and oceanographic (METOC) exploitation. The IDPS functionality will be offered (TBD) for commercial implementations (fixed or mobile) to be used by the worldwide civil METOC community.

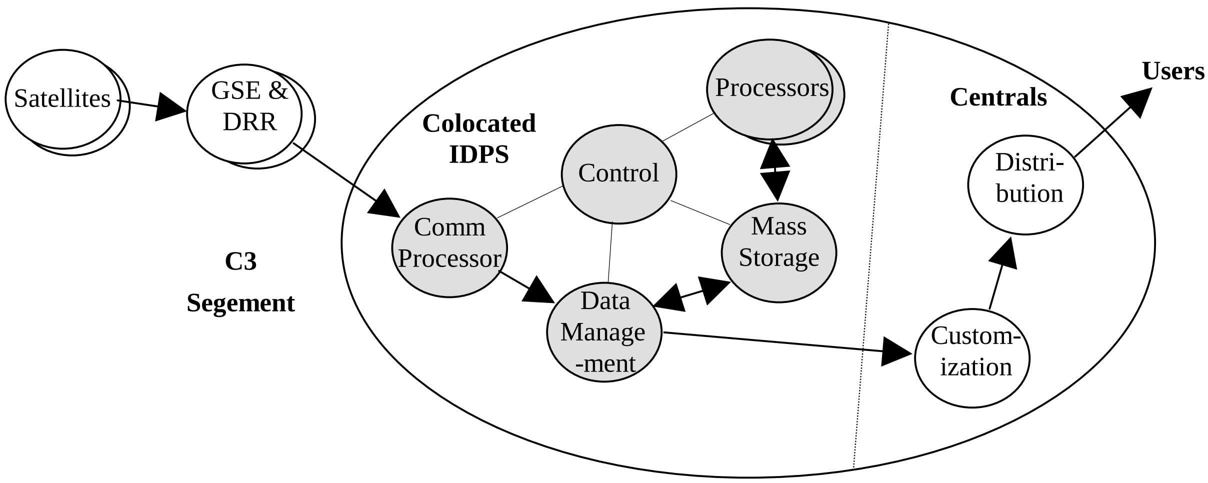

Figure 2-2. Notional IDPS Architecture and Environment (major flows)

2.2.1 Architectural assumptions

2.2.1.1 Number, location of central sites

At the present time, the geographic distribution of NPOESS RDR, SDR, and EDR processing sites is considered to consist of the five Central sites listed in the IORD-1. Ultimately, the number of Central sites might become a cost/benefit tradeoff against other Program requirements. The entire IDPS may be installed at one location; sequential processing may be installed at multiple locations (*e.g.*, RDR processing at a receiving site and SDR/EDR processing at a Central); or parallel processing may occur at multiple sites (*e.g.*, EDRs processed at multiple Centrals).

All (xDR) products must be available to all five identified Centrals based on their stated requirements.

The IDPS processing architecture must incorporate duplication and geographic diversity to assure robust product availability.

In addition, certain xDR processing will occur at geographically distributed DoD field terminals. As a goal, IDPS architecture should be such that DoD field terminals can operate a subset of the IDPS software to produce SDRs and EDRs limited only by their hardware capabilities and access to required auxiliary (non-NPOESS) data.

2.2.1.2 Single architecture

One generalized, high capacity architecture design will be installed at all locations. IPO will optimize performance by performing only those functions needed at each site, and by providing properly scaled hardware capacity.

Only one version of each required EDR product will be produced by the IDPS. Customization (including segmentation, projections, resampling, visualization, scaling, averaging, and annotation) will be performed for users by the Central which serves them or by supplementary software at the DoD field terminal.

2.2.1.3 Data-centric design

One cannot know which algorithms and data flows will be most successful and most useful through the life of the program. Improved knowledge of sensor performance, understanding of underlying environmental processes, and access to supporting data will lead to changes in NPOESS data processing before IOC and through the operational program. NPOESS must provide an architecture which provides common data resources (server, file structure, metadata) to multiple processors, which can host evolving processing functions.

Data files will be associated with metadata that describes the file contents and history. The metadata will contain information which enables the initiation of subsequent processing. For example, the arrival of a CrIS RDR can initiate CrIS SDR processing, which subsequently initiates sounder EDR processing, under the condition that the appropriate microwave sounder SDRs are also ready.

2.2.1.4 Single source for mission data

All space segment data required by IDPS at Centrals will be delivered by the C3S DRR. This will include data from NPOESS and METOP satellites. The single raw data stream will be in (TBD) format. The raw data stream will include all sensor and satellite mission data and telemetry needed for mission data processing to all xDRs.

Auxiliary data and other data (*e.g.*, calibrations) needed for mission data processing will be provided through (TBD: DRR or other) channels.

Within DoD field terminals, an independent element of IDPS will provide the necessary functionality provided by the Ground Station Element (GSE) and DRR for data transmitted to Centrals.

2.3 IDPS within NPOESS

Figure 2-3 shows the conceptual position of IDPS within the NPOESS-to-user environment. It also shows some of the major issues which are to be determined in the system design phase.

{to be fixed or deleted}

Figure 2-3. IDPS Within Overall NPOESS (To Be Revised)

3 Functions

This section describes the functions that will be performed within the IDPS, without making allocations to subsystems, and without defining the methods by which the functions are to be performed.

3.1 Communications

Communications services to and from IDPS sites will be provided by Data Routing and Retrieval (DRR) of the C^3S. Requirements will be established by (TBD).

(TBD) will provide communications with non-NPOESS sources, such as METOP, EOSDIS, NWSTG, and NESDIS, for operational data exchange. Such data may include SDRs from predecessor systems or auxiliary data files.

IDPS (TBR) will provide communications with collocated Centrals.

3.1.1 Communications interface at IDP-C

The IDPS to C^3S ICD[7] will specify the bridge (hardware, protocols, data rates, latency) between DRR and IDPS located at a Central.

The IDPS to Central ICD will specify the bridge (hardware, protocols, data rates, latency) between IDPS and local communications at a Central.

3.1.2 Communications interface at DoD field terminals

Provides data collection and raw telemetry processing.

3.2 Storage

3.2.1 Data representation

Data representation should be consistent within IDPS. Differing formats should be minimized. Data representations at IDPS interfaces should be consistent with accepted standards to the greatest possible extent.

The material which follows in this section is conceptual, representing a single possible IDPS storage structure.

3.2.2 File internal formats

File internal formats will be specified (for RDRs) or recommended (for SDRs and variants) by instrument contractors, compatible with their algorithms and other requirements. File internal formats for SDRs and EDRs will be specified by the IDPS contractor. File internal formats should be consistent with instrument file formats and user formats (*e.g.*, Gridded Binary [GRIB]) to the greatest extent possible.[8]

Figure 3-1. Top Level File Structure

[TBS]

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[7] The Program's IRD/ICD structure is not established, nor whether this will be an IPO or contractor-only issue.

[8] We intend to consider using or extending current product file formats whenever appropriate.

3.2.3 File storage formats[9]

A uniform file storage format will be used for all data files.

Files will be stored with uniquely identifying metadata (*e.g.*, origin, date, location, file ID, file type, size)

Functionally, file storage formats should provide components such as:

- A *Unique_file_ID* for identification within IDPS.
- *File_metadata*, which allows searching by principal data characteristics.

One or more pairs of the following:

- *Content_metadata* for understanding the file contents.
- A *Binary_file* or *Data_record* for holding the data proper (RDR, SDR, EDR, or other content).

The same overall structure should apply with minimal adjustment to RDRs, SDRs, EDRs, and auxiliary & ancillary data files.

3.2.4 Metadata

Metadata will include processing history, geographical coverage, quality, *etc*.

3.2.5 Data segmentation

Data files will be stored with sizes appropriate to processing level, application, and storage/processing efficiency.

3.2.6 Storage access

Storage will be designed such that any shared file may be accessed by a fixed, unique file identifier. The site storage structure will be hidden from the user.

3.2.7 Data retention

Data products will be retained in storage for up to (TBD) days, consistent with practices at the IDPS location and available storage media. Minimum data retention is (TBD from TRD). Data will be retained in anticipation of reprocessing, quality assurance, anomaly resolution, and trend analysis. Data will not be retained in IDPS for long term archives.

Table 3-1. Example File Structure

`[TBS]`

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[9] Notes: The "file storage format" is the logical association of minimum identification, metadata, and content elements. Content is formatted in any manner appropriate to the application. The physical implementation is for the system designers. Whether to use a relational database is also within the design space.

The IDPS file storage format needs to be efficient for IDPS processing, and needs to reflect current best practices. The IDPS contractor might adopt a <u>single</u> file storage format, as the most affordable solution to file management.

NPOESS would like to support a file storage concept which (a) meets the above criteria, and (b) is in use at Centrals, if such exists. IPO should provide toolkits for heritage systems to read any new formats. IPO cannot afford to adopt and maintain obsolescent designs, and should discourage others from doing so.

The metadata entails only a relatively small amount of data. It can be ignored at Centrals if not needed, but it can never be recreated if it is not collected along the way.

3.3 Processing

3.3.1 General

The objective of ground data processing is to produce estimates of specified environmental parameters, with specified measurement performance, at the time of observation from the spacecraft. To perform this in a logical manner, ground processing retraces the steps in observation, from the remotely-sensed environment to the space-to-ground telemetry channel. First, the telemetry stream transmitted by the spacecraft is recreated; this is called the CCSDS Level product in Figure 3-2. Then all sensors' and other subsystems' digital outputs are decoded and decommutated (RDR[10] Level). Next, the incident fluxes at the sensor inputs and other sensor performance parameters (*e.g.*, look direction) are recreated (SDR Level). Finally, the remote scene properties which produced the detected fluxes at the spacecraft are calculated or otherwise inferred (EDR Level). Synchronization between data streams from multiple sensors and other subsystems (principally attitude and ephemeris determination) is maintained by consistent time tagging.

The correspondence between defined product levels and physical implementation may be somewhat idealized, and may need adjustment for individual sensors. For example, certain communications processing takes place within some instruments. The figure shows packetization as being typical of this. The RDR thus may represent a data product that exists internal to the sensor.

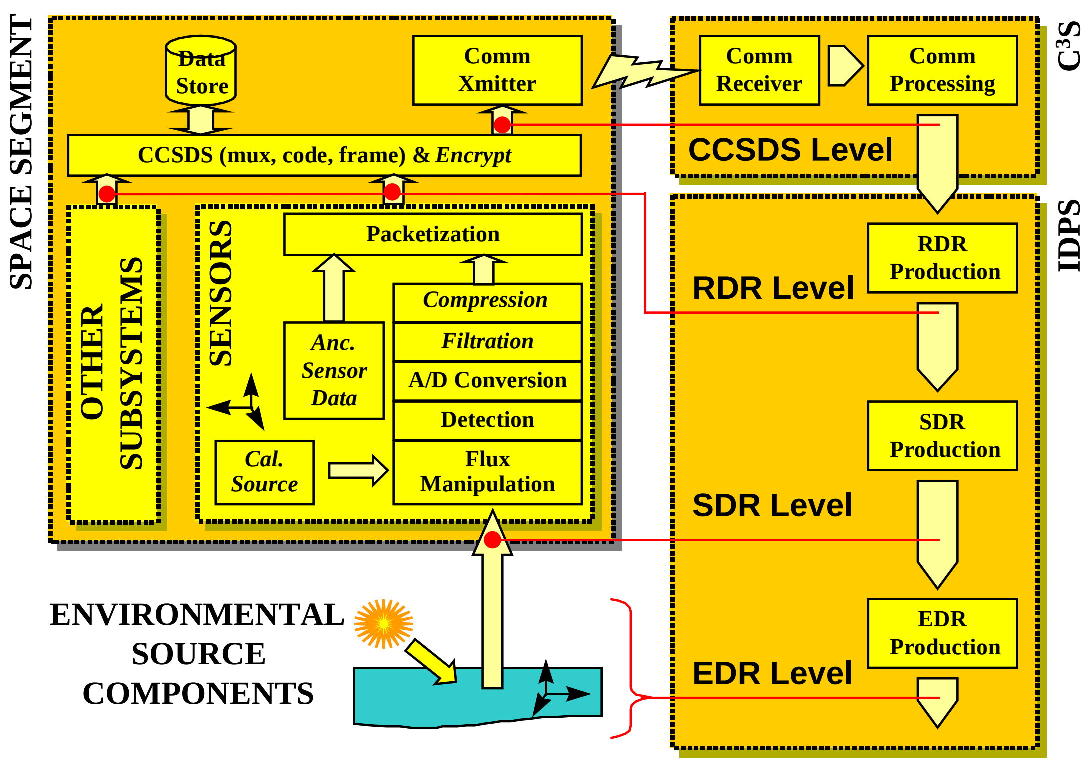

Figure 3-2. Correspondence Between Onboard Information Flow and Ground Data Processing

A significant attribute of these processing level definitions is that they simplify processing segmentation. RDR processing needs no external variable data. SDR processing is performed independently for each sensor, and

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[10] Detailed definitions (from TRD) and working interpretations for RDR, SDR, and EDR are given in Appendix C.

only needs information contained in the sensor RDR. EDR processing combines information from one or more sensors with information about the platform and (optionally) supplementary information from other sources.

Detailed processing descriptions from RDRs to SDRs and EDRs are found in Appendix D.

3.3.2 RDRs

Communications processing to produce RDRs recreates the continuous data streams that are produced by each instrument. RDRs have been processed for time sequencing, eliminating overlap[11], decommutating virtual channels, error detection and correction, decryption, marking/filling gaps, and logging quality.

RDR processing does not reduce information content of the received data stream.

3.3.3 SDRs[12]

SDR processing applies instrument calibrations and thereby recreates the physical measurement at the sensor input. To accomplish this, SDR processing decompresses data as appropriate; applies geometric and temporal inverse modeling to recreate an idealized spatial response; and applies bias, scale, and linearity compensation to the sensor digital output to recreate the measured flux at the sensor input. Because the fidelity of calibration and modeling is limited, SDR processing may be irreversible.

Table 3-2 summarizes the strawman data contents for the principal SDRs.

3.3.4 EDRs

EDR processing applies physical or empirical models that estimate an environmental parameter at or above the Earth based on measurements at one or more sensors. To accomplish this, EDR processing may incorporate resampling in space or time to create reports on a uniform grid or at global (lower) resolution[13]; projecting sensor data to the source; correcting for terrain and viewing geometry; associating geolocation coordinates; and producing individual products of IORD-specified temporal and spatial extent and resolution.

Each EDR is, in general, a single digital product. Users are responsible for customization, which includes: subsetting, resampling, mapping to alternative projections, content layout, annotation for specific applications, attaching headers, converting to alternative file formats, distribution on alternative media, *etc*.

EDRs will be produced in several steps from SDRs. The first step is to generate an empirical product which maps and converts sensor radiance to source radiance (*e.g.*, imagery). Subsequent steps convert the first-generation EDR into estimates of underlying physical phenomena (*e.g.*, ice type, vegetation index).

In some cases, the EDR will be nearly identical to the associated SDR. This is likely to be true for *in situ* measurements performed by sensors in the Space Environment Suite (*e.g.*, magnetic field vector measurements).

3.3.5 Contingency processing

EDR products must be produced with best possible quality when normal data sources are not available.

{add discussion}

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[11] Data overlap (redundancy from multiple station passes), not point-spread overlap.

[12] Microwave sensor measurements are sometimes reported as Temperature Data Records [TDRs], which represent the radiant flux entering the receiver viewing specific direction; that is, the incident radiant flux field integrated over the antenna response pattern. TDRs are identified in the IORD, but not the TRD. The IDPS requirement to produce TDRs instead of or in addition to SDRs for microwave sensors remains to be worked.

[13] In cases and at times when both regional and global coverages/resolutions are specified for a product, the system must specify whether both products are produced in the SpaceSegment or global resolution is synthesized in IDPS.

Alternate

{needs text} alternate data source allows most threshold requirements to be met

Backup

{needs text} backup data source allows product to be produced, with sub-threshold attributes

Table 3-2. Summary -- SDR Mission Data by Subsystem[14]

Sensor or Subsystem	Dependent Variable	Independent Variables
All		Time; satellite orbital position; **and**
CrIS	Spectral radiance	Wavenumber & *band#*; sensor position; cross-track angle
	[etc.]	

Key to variables: continuous variables; *discrete variables*

3.3.6 Data dependencies

Some EDRs depend on other EDRs or intermediate results of other sensor processing.

{add discussion}

{add table of known cases}

{add discussion of Fig. 3-4 & 3-5.}

Pipeline

Sequential use by one EDR process of the results of other EDRs.

Key issue in assuring timely EDR delivery.

Circular

Two or more EDR processes which depend for input on each other's output.

Resolved by iteration, reliance on ancillary data, or reliance on current predicted values (TBR).

[14] Certain thermal IR and microwave products are currently produced with radiances reported as brightness temperatures. We intend to ask the Centrals, the OATs, and the sensor contractors, if they have a consensus recommendation. Without further guidance, all measurands should be reported in Système Internationale (SI) "metric" units. The choice may be influenced by (a) the way the data is used, and (b) the way the data is calibrated. The true issue is that the contractors carefully define exactly what will be reported in measurements, not the name or units used.

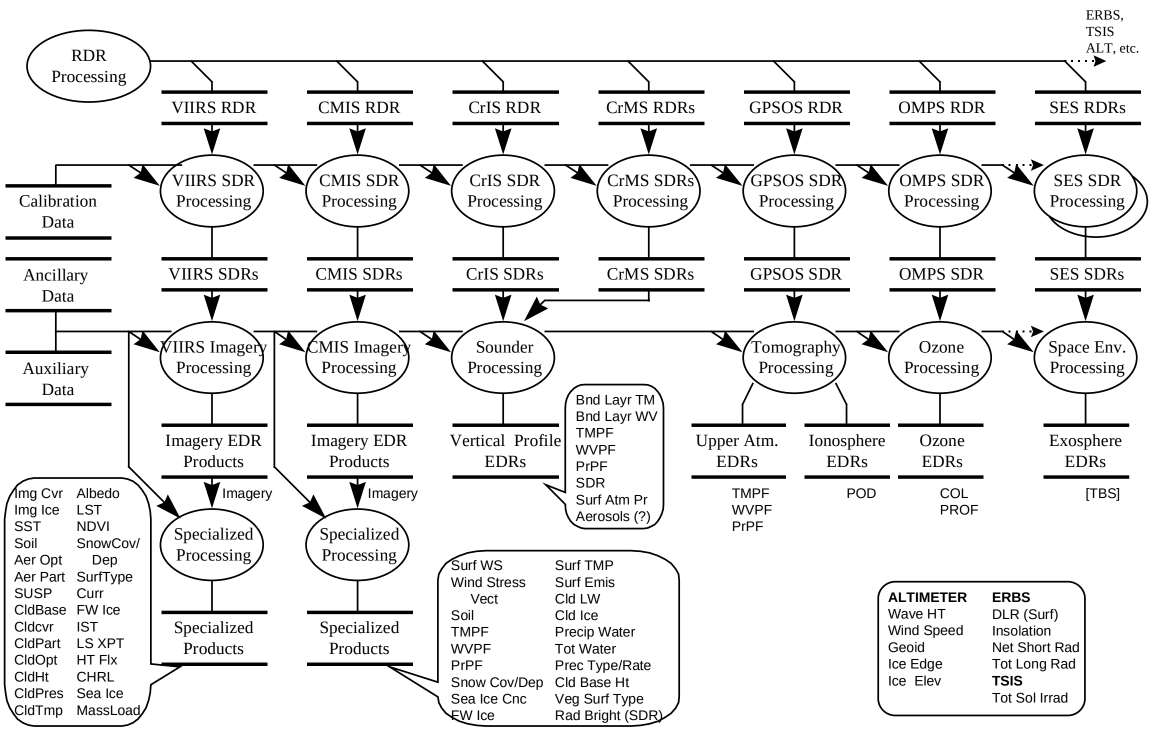

Figure 3-4. Basic Pipeline Data Flow (to be revised)

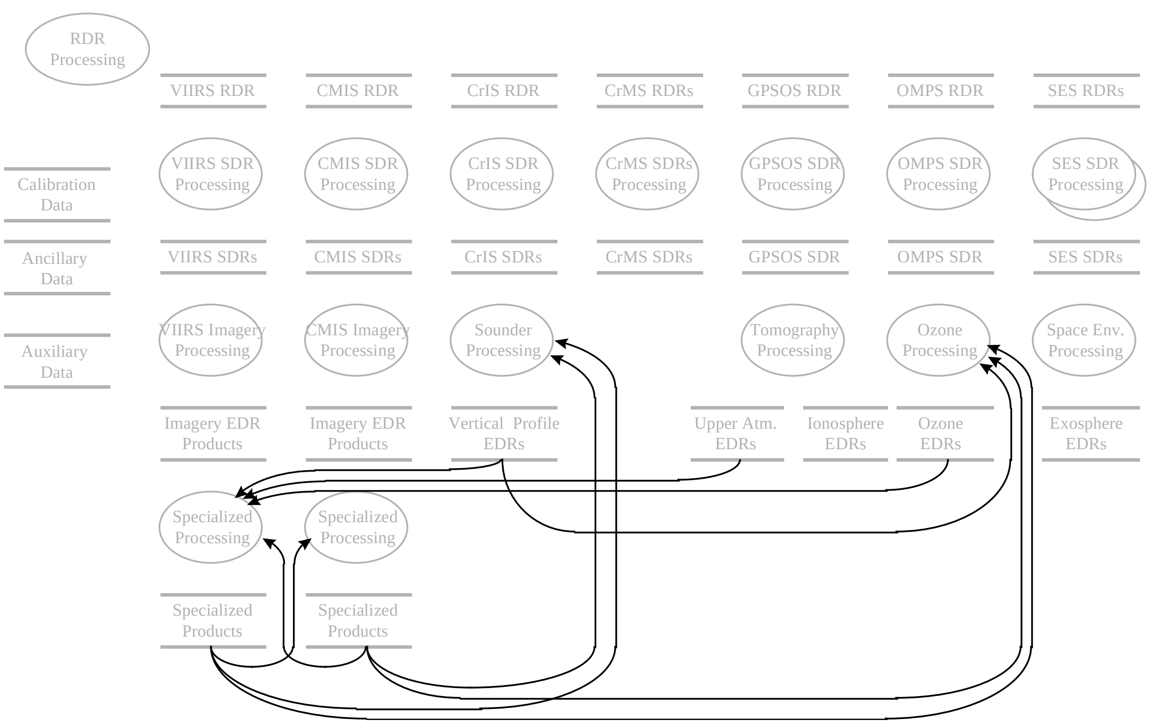

Figure 3-5. Data Flow Dependencies (to be revised)

3.3.7 Critical path(s)

The processing paths and dependencies which are most stressful to timely EDR production should be identified. Hardware and software derived requirements to meet EDR delivery must be allocated through the chain.

3.3.8 Support functions

IDPS will provide support functions which support the algorithms which produce all xDRs, and which enable performance requirements to be met. Examples of support functions are:

{to be expanded)

<u>Data management</u>

Tracking data through the system, applying appropriate processing.

<u>Scientific libraries</u>

Standard math & science libraries, including data manipulation and visualization tools.

<u>Compilation and linking</u>

<u>Startup/shutdown</u>

<u>Security</u>

<u>Operating systems</u>

<u>Database managers</u>

<u>Interprocess communications</u>

Send and receive data; signal process initialization and completion

<u>Process and fault logging</u>

3.3.9 Processing management

3.3.9.1 Scheduling

The scheduling function will incorporate process initiation, task sequencing, and status tracking and reporting.

{more}The scheduling system must accommodate several potentially conflicting factors

(a) Data processing must be accomplished with demanding timeliness requirements.

(b) Data arrival times and sources are uncertain.

(c) Processing priorities may change, either slowly over time with changes in product priorities, or suddenly due to emergency conditions.

(d) Specific equipment items may be unavailable.

(e) Not all auxiliary data may be available when processing must start.

{more}

3.3.9.2 Processing initiation

(TBS)

3.3.9.3 Resource allocation

(TBS)

3.3.9.4 Task prioritization

(TBS)

3.3.9.5 Accounting and tracking

(TBS)

3.4 Data quality assurance

(TBS)

3.5 Simulators

(TBS)

The Integrated Weather Products Testbed (IWPTB) will serve as a pathfinder for end-to-end system performance simulation. The transition from IWPTB to operational simulation is (TBD).

3.6 Functions performed in DoD field terminals

3.7 Calibration

4 Interfaces[15]

This section establishes where interfaces exist, and identifies what aspects of interfaces must be controlled.

4.1 Definitions

4.1.1 Physical interfaces

The manner in which two systems connect, mechanically and electrically (or equivalent). Corresponds to Open Systems Interconnect model layers 1 and 2.

4.1.2 Software and logical interfaces

The manner in which data and control is exchanged between two systems. Includes communications protocols; establishing connections; transmitting, acknowledging and verifying data.

4.1.3 Operator interfaces

(TBS)

4.2 Data source interfaces

4.2.1 Satellites

The source data for the IDPS includes all sensor data and spacecraft subsystem ancillary data, such as subsystem status, guidance & navigation (location, attitude), out-of-limits conditions, operating modes, *etc*.

4.2.1.1 NPOESS Satellite

The NPOESS satellite interface will be through the CCSDS formatted data downlink from the satellite through the C^3 Segment (C^3S). Sensor and platform data will be formatted in predefined Virtual Channels (VCs) within the data stream. Mission (science) and housekeeping (engineering) data will be included in the data stream. All mission data and routine housekeeping data will be included in a normal operating format used for playback at C^3S ground stations. Other formats will be used in non-operational modes. Other CCSDS formats, at lower (TBD) data rates, will be used for direct downlink data transmission to other stations worldwide, including DoD field terminals. VC allocations and contents will be defined in a Data Format Control Book (DFCB) .

4.2.1.2 METOP

IDPS will receive selected instrument data from METOP satellites operated by EUMETSAT via C^3S. IDPS will accept METOP data as (TBD) xDRs and process them into NPOESS standard EDRs for distribution to US users.

{Communications support between METOP and EUMETSAT through U.S. CDAs is provided by C^3S}

4.2.1.3 NPOESS Preparatory Program (TBD)

Certain NPOESS sensors may fly on a demonstration satellite before the first operational mission. An early-version of IDPS will be required to provide limited operational ground processing for this demonstration mission.3.2.1.4 POES and DMSP

During the transition period, when both NPOESS and heritage (DMSP & POES) satellites are in orbit, interfaces with and EDR processing for those systems will be provided by the appropriate heritage ground systems.

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[15] Supporting details will be in the Interface Description Document (IDD), a separate document.

4.2.2 Payloads

Includes METOP instruments used to complement NPOESS instrument data.

4.2.2.1 General

Each instrument will use one or more unique Virtual Channels to carry its data. Multiple mission and housekeeping data types may be multiplexed on a single VC, or allocated to different VCs. The content of each VC and whether a VC is produced at all may depend on the current mode, and may change from time to time based on payload reprogramming.

Sensors may apply various compression algorithms to data before packetization into Virtual Channel Data Units (VCDUs). Compression may require additional error coding to achieve the required end-to-end bit error rate (BER). The sensor will provide the error detection and correction (EDAC) and decompression algorithms to be used in ground RDR processing.

4.2.2.2 Heritage payloads

Existing payloads may not generate data in a CCSDS VCDU format. Such data may (TBD) be formatted (converted or wrapped) to comply with the CCSDS standard by the spacecraft C&DH.

4.2.2.3 NPOESS payloads

(TBS)...

4.2.2.4 SARSAT

Low rate digital housekeeping data from SARSAT will be transmitted to NESDIS (operations) without further processing (TBR) immediately upon decommutation from the instrument data stream. SARSAT mission data is transmitted directly from the SARSAT payload, and is not considered within IDPS.

If C^3S strips SARSAT housekeeping from CCSDS telemetry, IDPS is not involved in its processing.

4.2.2.5 DCS

Mission data collected by DCS must be transmitted to Service ARGOS (Largo, MD) via NESDIS (TBD) without further processing upon decommutation from the telemetry stream.

If C^3S strips DCS VCDUs from CCSDS telemetry, IDPS is not involved in its processing.

DCS mission data is also transmitted in real time directly from the DCS payload to ground receivers; that return communications channel is not considered within IDPS.

4.2.3 Ancillary[16] system data

Ancillary data comprises other data which is generated within the NPOESS. Enough ancillary information will be transmitted to the ground to permit proper understanding and processing of the mission data. In some cases, status flags will be sufficient; in many cases, actual parameter values will be needed.

4.2.3.1 Spacecraft ancillary data

The ancillary data generated onboard the spacecraft will be sent to each sensor for incorporation in each sensor formatted data stream for use by the IDPS in processing mission data.

The following ancillary data items are examples of those which should be provided:

- [TBS]

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[16] Based on the *CEOS Lexicon* at <http://www.eos.co.uk/ceos-wgiss/CEOSLexicon.htm>, which defines "ancillary data" as originating from the spacecraft, and defines "Auxiliary data" as originating elsewhere.

4.2.3.2 Ground ancillary data

Ground ancillary data will be required for IDPS processing. It is available to IDPS sites from other NPOESS ground elements. It will be provided to the spacecraft for broadcast to tactical sites

- [TBS]

4.2.4 Auxiliary data

Auxiliary data originates outside NPOESS. The IDPS will provide the auxiliary data required for nominal and contingency EDR production. These data, their attributes, and the specific sources from which they are obtained will be specified by the appropriate instrument contractors.

For convenience, auxiliary data is subdivided into quasi-static and dynamic.

4.2.4.1 Quasi-static data

Quasi-static ancillary data will be refreshed infrequently, as required. In general, IDPS need not automate procedures for infrequent updates.

Topography

The IDPS will maintain an updated global digital elevation model. Quality requirements will be defined in (TBD)

Geomagnetic field model

Magnetic field strength is potentially needed in microwave sounder algorithm to compensate for line shape change.

Map projections, datums, and geoids

This data provides the mathematical basis for precision data mapping.

Surface cover type atlas

A surface cover type atlas is used to understand the typical radiometric characteristics of the Earth surface.

Surface cover characteristics

For each type in the atlas, information such as

- bi-directional reflection distribution function (BRDF)
- microwave and IR emissivity
- {other}

Standard climate data

Standard land, ocean, and atmospheric parameters, with their diurnal and seasonal variations, which can be used to initialize algorithms in the absence of more timely and accurate data; *i.e.*,

- T, P, Q, ozone, SO_2 profiles
- average winds (TBR)
- aerosols
- cloudcover structure (TBR)

Other (TBD)

4.2.4.2 Dynamic data

Dynamic data will be refreshed periodically, as determined by the associated EDR algorithms.

The IPO must determine and specify whether dynamic data is provided in the form of most recent observation, or in the form of an assimilated product that has been temporally extrapolated and spatially interpolated through NWF to the satellite observation time and location.

Standard products are (TBD) available in WMO standard formats from the NWS Telecommunications Gateway (NWSTG) or AWIPS NOAAPort.[17]

Dynamic data will be updated within IDPS automatically, or using automated tools.

4.2.4.2.1 Assimilated weather products

- global sea surface winds
- aerosols (including smoke and volcanic ejecta)
- T, P, Q, ozone, SO_2 profiles
- cloudcover structure

4.2.4.2.2 *In situ* Observations

- Rawindsonde observations
- Surface hydrometeorological observations, including temperature, soil moisture, snow conditions
- Ship, ice drifter observations

4.2.4.2.3 GPS ground network observations

IDPS will (TBR) receive GPS observations from multiple worldwide ground stations. Observations may be GPS satellite pseudoranges (comparable to SDR level), or precision GPS satellite orbits (comparable to EDR level). IDPS will produce best –estimate retrospective orbits for all GPS satellites in time to support GPSOS EDR processing.

[TBW: We assume here that this is "auxiliary data", but it could alternatively be considered a special type of (RDR) data? The issue may depend on the extent of processing to be provided within IDPS.]

4.2.4.3 Sensor calibration data

Ground calibration data. Each sensor will provide IDPS with initial calibration data based on ground testing at the component and system level. The sensor contractor will indicate which calibration elements should be updated after launch, and under what conditions.

Orbital calibration data. Each sensor will provide IDPS with operational procedures to update long-term calibrations while on orbit. These procedures may include long-term trend analysis, standard scenes (Earth, Moon, or space), or coordinated calibration campaigns with other sensors. IDPS must provide an off-line capability to support this calibration activity. The capability may be (TBD) part of the operational system (*e.g.*, provided by a spare or redundant system) or a separate facility (e.g., provided through a continuing sensor engineering support contractor).

[TBW: How is the initial on-orbit and sustaining calibration function to be supported?]

Short term calibration is considered part of normal data processing.

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[17] A common source for each auxiliary data item is the assumed baseline. One goal of the IDD is to enable the consideration of what we need, how rapidly and how often to support the IDPS algorithms. The suitability of using locally-provided auxiliary data needs to be evaluated against IDPS design complexity and maintainability.

4.3 User interfaces

4.3.1 General

Standards

IDPS will adopt industry standards for data delivery and communications with Centrals.

IDPS will adopt meteorological standards (WMO or OFCM) or industry standards for formatting data deliverable to Centrals.

IDPS will select standards in consultation with the Centrals, and will offer a range of standard interfaces that attempt to accommodate individual situations and future expansion. However, each Central must anticipate that some adaptation will be required within their systems to accommodate the IDPS interface.

NPOESS assumes that data files will be provided to Centrals from an FTP server or equivalent[18]. Centrals will be advised that a data product is available by a brief "advertising service" message. The advertising service broadcasts to "subscribers" the new file's contents, the unique file designation, and its location.

Data formats

Metadata and Files: [TBD]

Data representation:[19]

Binary data:	BUFR
Gridded data:	GRIB
Geospatial data:	FGDC Spatial Data Transfer Standard (SDTS)
Imagery data:	JPEG(?)

4.3.2 Centrals

4.3.2.1 General

This section incorporates common user interface attributes with Centrals. Specific items for the five identified Centrals are given in the sections which follow.

Routine DR delivery (outward)

RDRs, SDRs, EDRs, other products, and associated metadata required by Centrals will be produced on a routine schedule and will be placed on a firewall-protected file server. For convenience, all or most RDRs, SDRs, and EDRs, may be placed on the server.

An "advertising service" , a dynamic list of processed products, or some other mutually agreeable mechanism should be adopted to notify Centrals about which xDRs are ready.

Special DR delivery (outward)

[TBD].

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[18] The procedures and systems which provide the NOAA/DoD Shared Processing Program (SPP) may represent a viable implementation for data product transfer to Centrals. (See: *Program Operations Manual for the NOAA/DoD Shared Processing Program*, NOAA NESDIS, September 1998; and OFCM, *Interdepartmental Meteorological Data Exchange System Report,* FCM-R12-1998, August 1998.)

[19] These formats are generally consistent with Federal standards, and specifically consistent with DoD COE and the *Reengineered AF Weather (AFW) End-State Architecture* (Draft Release 1.0), May 1998.

Auxiliary data return (inward)

IDPS will establish procedures for requesting and accepting products produced at Centrals for use as ancillary data in EDR processing. These products will be accepted in source-standard format.

Administrative messaging

Administrative messaging between each Central and the IDPS will be based on the (TBS) e-mail protocol. Messages may be from or to both operations personnel and designated automated functions on both ends.

Facility support

IDPS sites hosted at Centrals will be provided with (TBD) space, power, light, environmental control, communications access, general maintenance, (&c.)

Operations support

IDPS sites hosted at Centrals will be provided with (TBD) operations staff, supplies, technical maintenance, physical security, (&c.)

4.3.2.2 AFWA

4.3.2.3 OSDPD

4.3.2.4 FNMOC

4.3.2.5 NAVOCEANO

4.3.2.6 55 SWxS

4.3.3 Direct users

IDPS functions will be hosted in DoD field terminals, requiring a physical interface with the DoD field terminal hardware and a logical interface with the broadcast telemetry stream and the host system environment.

[TBS]

4.3.4 Flight operations

IDPS will provide (TBR) telemetry retrieved from spacecraft data stream and selected mission data from the payload data stream. [TBW: does telemetry get stripped out in the C^3 Segment?]

IDPS will provide calibrations, quality assessment, and trending analysis on the instrument data.

4.3.5 Data product definitions

Provisional, working definitions for standard data products are found in Appendix C.

{add revised text which is to the point of this section}

4.4 Internal

(TBS)

5 Performance requirements

6 Facilities and equipment

7 Development and transition

7.1 Algorithms

SDR and EDR processing algorithms are initially responsibility of the appropriate instrument contractor.

Contractors will provide a narrative and mathematical description of each algorithm in an *Algorithm Theoretical Basis Document*; annotated working code which implements the algorithm in an acceptable high level programming language; and validated test runs.

The TSPR contractor will define standards for submitted algorithms and code. The TSPR contractor will provide a software toolkit that provides access to IDPS data and services for use by submitted algorithms.

7.2 Documentation

7.3 COTS and open systems

7.4 Configuration management

7.5 System startup transition

8 Operational concept

9 Roles and responsibilities

Appendices

A. TBx and identified open issues in this document

Reference	*Question or Issue*
	TO BE SUPPLIED

B. Acronyms

AFSCN	Air Force Satellite Control Network
AFWA	Air Force Weather Agency
AIP	Advanced Information Processor
AMSU	Advanced Microwave Sounder Unit
AWIPS	Advanced Weather Information Processing System
BER	bit error rate
BRDF	bi-directional reflection distribution function
BUFR	Binary Universal Form for the Representation of meteorological data
C3S	Command, Control, and Communications Segment
CCSDS	Consultative Committee for Space Data Systems
CDA	Command and Data Acquisition
CEMSCS	Central EnvironMental Satellite Control System
CrIS	Cross-track Infrared Sounder
CrIMSS	Cross-track Infrared and Microwave Sounder Suite
DCS	Data Collection System
DEM	digital elevation model
DMSP	Defense Meteorological Support Program
DFCB	Data Format Control Book
DR	data record
DRR	Data Routing and Retrieval
DSP	digital signal processor
EDAC	error detection and correction
EDR	environmental data record
EOSDIS	EOS Data and Information System
FCDB	Format Control Data Book
FDD	Functional Description Document
FGDC	Federal Geographic Data Committee
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FTP	File Transfer Protocol
GPS	Global Positioning System
GPSOS	GPS Occultation Sounder
GRIB	Gridded Binary
GSE	Ground Station Element
HDF	Hierarchical Data Format
HRD	High Rate Data (direct)
HTTP	HyperText Transfer Protocol
IDD	Interface Description Document
IDPS	Interface Data Processing Segment
IDP-F	IDP for DoD field terminals

IOC	Initial Operational Capability
IORD	Initial Operational Requirements Document
IDR	Interface Requirements Document
IJPS	Interim Joint Polar System
JPEG	Joint Photographic Experts Group
LRD	Low Rate Data (direct)
METOC	meteorology and oceanography
MHS	Microwave Humidity Sensor
NAVOCEANO	Naval Oceanographic Office
NESDIS	National Environmental Satellite, Data, and Information System
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Satellite System
NWF	numerical weather forecasting
NWSTG	National Weather Service Telecommunications Gateway
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
OSDPD	Office of Satellite Data Processing and Distribution
QA	quality assurance
RDR	raw data record
SARSAT	Search and Rescue Satellite
SDHS	Satellite Data Handling System
SDR	sensor data record
SDTS	Spatial Data Transfer Standard
SEC	Space Environment Center
SMD	Stored Mission Data
SOCC	Satellite Operations Control Center
SPP	Shared Processing Program
SRD	Sensor Requirement Document
SST	sea surface temperature
SWxS	Space Weather Squadron
TBW	to be worked
TBx	TBD, TBR, or TBS
TDR	temperature data record
TOA	top of atmosphere
TRD	Technical Requirements Document
URL	Uniform Resource Locator
VC	Virtual Channel
VCDU	Virtual Channel Data Unit
WMO	World Meteorological Organization
xDR	RDR, TDR, SDR, or EDR

C. Definitions

C.1 Communications link terms

Element

Mission data

Segment

Telemetry

C.2 Ancillary and auxiliary data[20]

Ancillary data are data which are not originated within the sensor itself and have the primary purpose to serve the processing of instrument data. This can be divided into spacecraft ‘engineering’, ‘core housekeeping’, or ‘subsystem’ data from other parts of the platform and includes parameters such as orbit position and velocity, attitude and its rate of change, time, temperatures, jet firings, internally produced magnetic fields, and other environmental measurements.[21]

Auxiliary data are data which enhance processing and utilization of sensor data. The auxiliary data are not captured by the same data collection process as the sensor data. Auxiliary data include data collected by any platform or process.

C.3 Data product definitions as used in this FDD

The following are provisional, working definitions for standard data products. They are unlikely to be the final definitions, and will need additional explanation before being used for all processing streams. These definitions elaborate on those found in the TRD, which derives from the IORD-1.[22]

1. Raw Telemetry

Raw telemetry is the serial digital data stream from spacecraft, usually binary, detected and synchronized within the receiving system. Files are identified by source and collection parameters (receiver channel, receipt time, receipt site, quality).

Precise definition(s) of telemetry will be provided by the C^3 Segment.

The processed telemetry will consist of complete CCSDS Virtual Channel Data Units (VCDUs), as defined by CCSDS *Advanced Orbiting Systems, Networks and Data Links: Architectural specification*, CCSDS 701.0-B-2 (Blue Book), November 1992.

Purpose: collect spacecraft data stream in a format suitable for digital processing

Content: bit stream; time tag; acquisition parameters

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[20] Based on *Auxiliary Data in the CEOS Community: Part 1*, Issue 2.00, January 1996, available at URL <http://www.eos.co.uk/ceos-wgiss/intro.htm>.

[21] This “ancillary data” definition is consistent with the terminology in CCSDS 701.0-B-2 *Recommendations for Advanced Orbiting Systems*.

[22] See Appendix C.4.

Format: binary; segmented (TBD)

Processing: demodulate, bit-synch, convolution decode, pseudonoise decode, frame-synch (TBD), record

Algorithm resource: C^3S

2. Raw Data Record

A Raw Data Record (RDR) is a time-delimited recording of one physical digital data stream, consisting of one or more multiplexed logical data streams, all originating from one specific spacecraft or sensor subsystem. Contains mission and housekeeping data from the subsystem. Communications artifacts (e.g., framing, convolution coding, error detection and correction coding [EDAC], encryption) have been removed, leaving only the subsystem's data output. Data have been reordered to match the time sequence in which they were created; duplication has been removed and missing data filled or flagged. File structure is subsystem specific, with some common elements. File size is subsystem-specific, within defined system limits.

RDRs will contain the ancillary calibration data (*e.g*., radiometric and geometric) needed for SDR and EDR processing, imbedded periodically in the broadcast data stream.

RDRs will contain information for geolocation (*i.e*., onboard-estimated (TBR) spacecraft attitude and ephemeris), associated with the mission data by time tag.

Ancillary data will be inserted by the sensor into its output data stream. Ancillary data may originate within the sensor (*e.g*., operating temperature), in the spacecraft (*e.g*., orientation), or on the ground (*e.g*., certain calibration coefficients).

Purpose: collect each sensor output data stream in a format suitable for sensor-specific processing

Content: VCDUs for the appropriate sensor

Format: octet files, partitioned into convenient file size ("granule") for further processing

Processing: remove communications artifacts (*e.g*., demultiplexing, packetization, convolution coding, EDAC coding, compression coding, encryption); reorder in time sequence; remove duplicates, fill missing data; associate ancillary RDRs (*e.g*., calibration data, attitude, ephemeris).

Algorithm resource: spacecraft contractor

3. Sensor Data Record[23]

A Sensor Data Record (SDR) is a collection of data processed to represent the measured flux data at the sensor input. Data sets are corrected for sensor artifacts, such as responsivity (linearity, bias, hysteresis, scatter), geometry (distortion, jitter, misalignment, point spread, temporal response), and data manipulations (transforms, compression, data buffering and sequencing). Data sets may be processed for scan, channel, and detector geometry (*e.g*., spectral registration). In general, only sensor data are required to produce an SDR.

File format usually includes an n-dimensional array of corrected measurement values converted to physically meaningful units, as a function of one or more measurement parameters (time, direction, channel #, frequency, energy). File format also includes a nominal projection onto a simplified geoid for geolocation. File structure is subsystem specific, with some common elements. File size is subsystem-specific, within defined system limits. Each SDR will include identification and processing history information which simplify understanding the data.

Purpose: collect best estimate of flux (or other measurand) distribution at the sensor input

Content: an array of measured values for each sensor channel, in physically meaningful units

[23] This definition is intended to be consistent with the TRD definition, while rationalizing and extending it.

Format:	(1) measurements typically organized by scan line, partitioned into a convenient file size for processing and distribution, containing all channels for an observed area (2) associated records provide look direction for each measurement, sensor location and attitude (3) associated records provide the nominal surface intercept (on a simplified geoid) for each measurement
Processing:	remove information processing, detection, scan, and radiant flux manipulation distortions
Algorithm resource:	sensor contractor

4. Environmental Data Record

An Environmental Data Record (EDR) is a collection of data that represent one or more related environmental variables, generally referenced to the originating location. Environmental variables are reported in physically significant units at the source, and geometrically referenced with respect to the Earth or other appropriate coordinate system being measured. Often, some data originating outside the IDPS will be needed to produce EDRs.

Data may be represented on a uniform or non-uniform grid in space and time, as appropriate to EDR. File structure is EDR specific, with as many common attributes and structures as possible. File size is EDR-specific, within defined system limits. Each EDR will include identification and processing information which simplify understanding the data.

EDRs tend to be of two types, which need not always be explicitly differentiated. The first type comprises source physical variables that were derived from sensor variables. For example, an imagery irradiance SDR in swath coordinates is mapped to surface radiance EDR in geodetic coordinates. The second type comprises geophysical variables that were derived from source physical variables. For example, mapping scene spectral radiances into surface type classification or aerosol properties.

Purpose:	collect an estimate of environmental parameters
Content:	environmental parameters located in Earth coordinates
Format:	standard file structures (*e.g.*, GRIP, BUFR)
Processing:	project SDR onto TOA or surface, resample, fuse with other data sources, and apply environmental models as appropriate
Algorithm resource:	OAT

5. Internal EDRs

Internal EDRs are EDR-like products which are used internally by IDPS, and not deliverable to users.

C.4 Data product definitions from the TRD

From the *DRAFT SYSTEM TECHNICAL REQUIREMENTS DOCUMENT*, 17 March 1997, updated through 4 Aug 98:

{text from TRD and analysis will be inserted here}

D. Algorithm processing and data dependencies

These summaries are organized by nominal processes, not EDRs. One or more related EDRs result from each process.

In future versions, sequential SDR and EDR processing will be segregated, since the former is tightly associated with sensors, and the latter is tightly associated with defined products.

Processing to produce RDRs is essentially a communications task, unrelated to specific sensors or products. All xDRs (except internal EDRs) will be placed in short term archives , available to users for custom applications.

D.0 Sample Process Format

Replace with process name

Top level. Processes may be decomposed by others.

D.0.1 Inputs

Identified as to whether Primary data source (full output quality expected), Alternate data source (some thresholds not achieved), or Contingency data source (output significantly degraded)

D.0.1.1 RDRs

Typically, one RDR should be expected as input for each process.

D.0.1.2 SDRs

Usually, no SDRs are expected as input.

D.0.1.3 EDRs

Any number of EDRs may be useful in processing. A process may require an EDR which is not an IORD-specified output of the system.

D.0.1.4 Ancillary

Spacecraft or other NPOESS data required or useful for SDR & EDR processing.

Examples: supply voltage, temperatures, attitude, orbit, processing history

"(d)" means dynamic, "(s)" means static in reference to auxiliary and ancillary data.

D.0.1.5 Auxiliary

Non-NPOESS data needed for processing, usually for EDRs only.

Examples: digital elevation model (DEM), landcover atlas, rawindsonde data, current data assimilation model, recent forecast output, local statistical climatology

D.0.2 Process

D.0.2.1 SDR Processing

One or more steps required to produce related SDRs. Process steps may be parallel or serial

D.0.2.2 EDR Processing

One or more steps required to produce related EDRs. Process steps may be parallel or serial. Different steps may be required to produce EDRs based on alternate input data availability.

D.0.3 Outputs

D.0.3.1 SDRs

For internal use and specialized use by others.

D.0.3.2 Primary System EDRs

Deliverable system output

D.0.3.3 Secondary System EDRs

Those for which another process has primary responsibility.

D.0.3.4 Internal EDRs

Used by other processes.

Example: cloud mask

D.0.4 References